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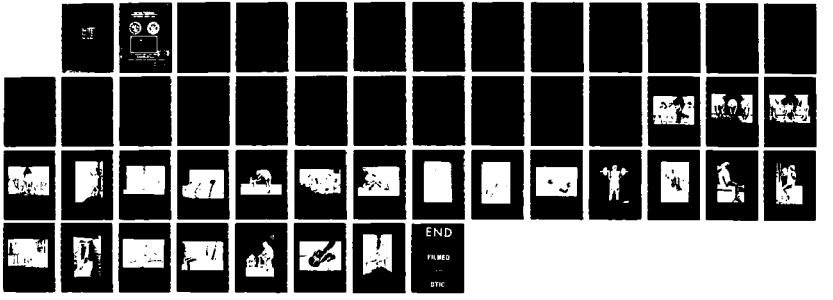

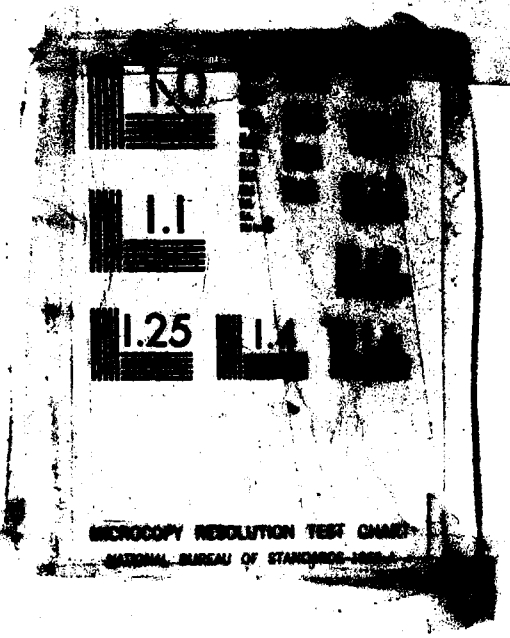
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PHYSICAL FITNESS TRAINING PROGRAM FOR RESEARCH SATURATION DIVERS

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NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND

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A physical fitness training program is described for diver research subjects. The program incorporates the concepts of strength and endurance into total body fitness. Special emphasis is placed upon specificity training for appropriate research projects. The training program is divided into two phases. Phase I is the entry level into the program. This phase lasts four to six weeks and is geared to bring all diver subjects to an equivalent level of physical fitness regardless of prior training. Exercise sessions include circuit weight training, running, and swimming. All exercise sessions begin with warm-up and stretching routines, and conclude with cool-down stretching routines. Phase II of the training program involves higher intensity circuit weights, running, and swimming. In addition, specific exercises are included that relate directly to the research mission requirements. The flexibility of the training program allows it to be implemented under a variety of circumstances. Phase I of the program enables

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all divers to be maintained in a state of physical readiness regardless of the mission requirements. Suggestions are offered for the implementation of the program and for program modifications. Key words:

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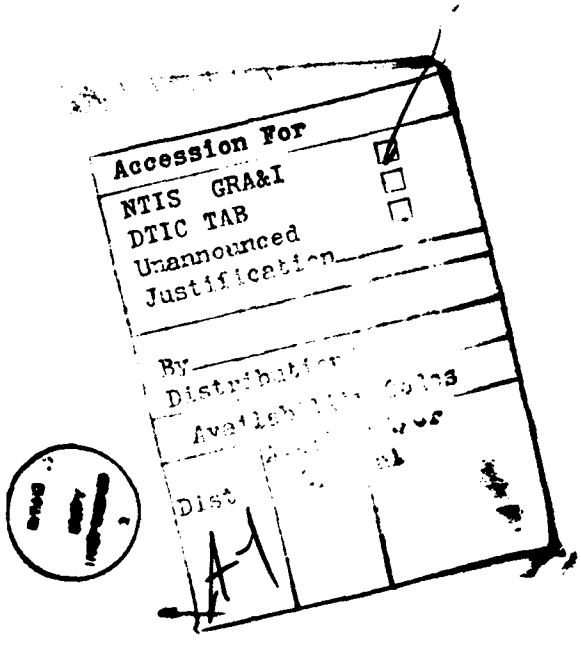


TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page Number

LIST OF APPENDICES

INTRODUCTION

There is a well recognized need for physical fitness in diving environments. Fitness training programs may vary widely from one diving command to another. Often the patterns of exercise are random and left to personal preference. Establishment of fitness criteria depends heavily upon the nature of the diving operation. In research, diving fitness includes a high degree of specificity for the research activities. Individuals not trained specifically for a research task may undergo a training effect during the conduct of the research (MacDougall, 1977; Saltin, 1968) thereby biasing results.

This paper describes the physical training program developed at the Naval Medical Research Institute for initial research saturation dives to 1,000 ft of seawater. The principles contained in the program can be adapted suitably for other research dives, operational diving, or general fitness programs. Further, the program should be implemented and maintained for all divers regardless of age or sex.

PRINCIPLES OF THE TRAINING PROGRAM

The first principle of this training program relates to total body involvement. Exercise routines were developed specifically for the arms, legs, trunk, and abdomen. Particular muscles were used in different motor patterns and over wide ranges of motion. The principle of total body fitness prepares the diver not only for the research task but also enhances his or her overall well-being during hyperbaric exposures.

Principles of dynamic strength training were applied over full ranges of motion. Endurance training was applied through several different exercise modes to increase aerobic capacity. Stretching exercises were used throughout

the training program to enhance flexibility and reduce the probability of injury.

The principle of specificity was incorporated into the training program. Forearm grip strength and bicycle ergometric exercises were required for our inaugural saturation dives. The specificity of this training was achieved directly through task specific exercises of handgrip maneuvers and bicycle pedaling.

Variety was incorporated into the training schedule to prevent boredom and to maintain a high level of interest. Major exercise routines were done on alternating days to provide variety. The training was structured as a group activity, in part to maintain high levels of motivation through peer pressure, and also to observe interactions among members of the dive team.

Personal progress during the training program was monitored subjectively and objectively.

TRAINING PHASES

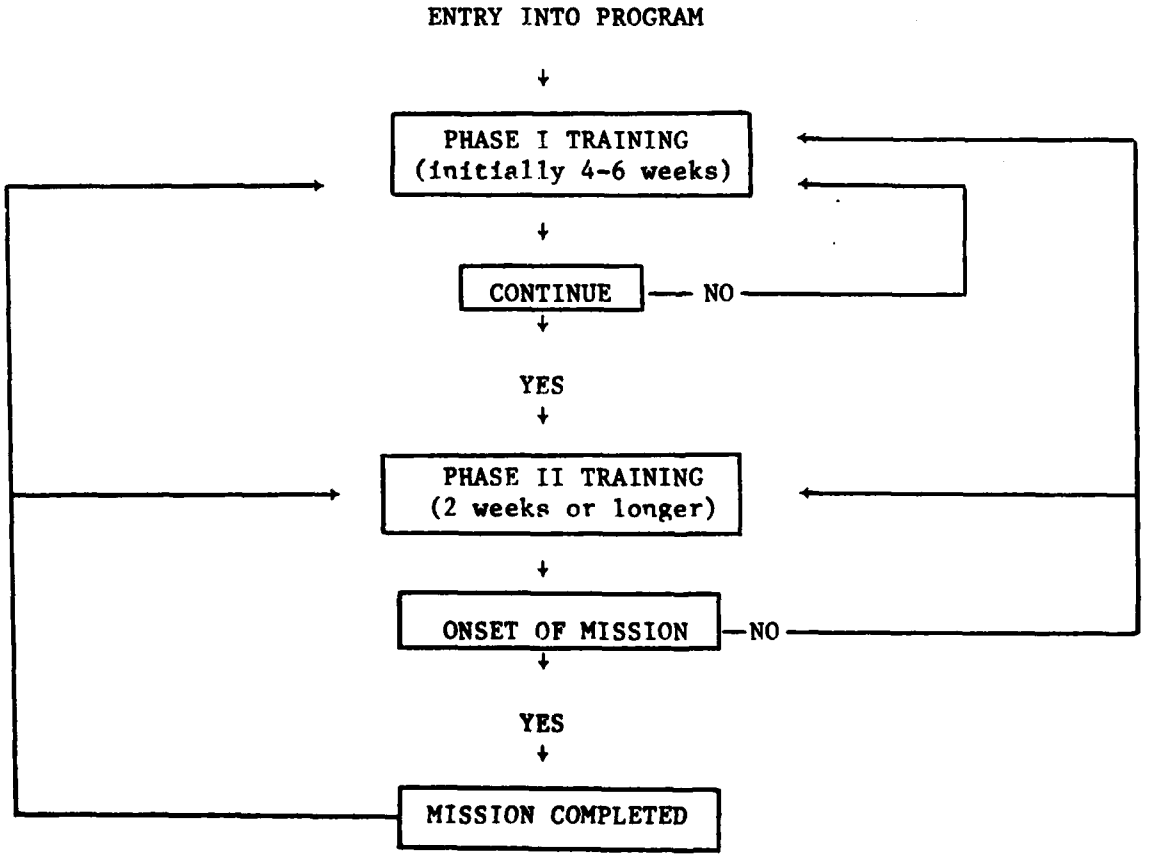
A flow diagram for the fitness program is illustrated at the end of this section. Criteria for entry is assumed to be the physical status of the average healthy individual. Medical evaluations may be necessary for persons older than 35 years.

Phase I was designed to bring all dive team members to the same approximate level of fitness. This phase lasts four to six weeks and depends upon entry level fitness, operational considerations, and dive scheduling. It is important to note that the four to six week duration of this phase is needed in order to expect significant gains in fitness (American College of Sports Medicine, 1980). Crash programs attempting to improve fitness in shorter periods have failed invariably (Dressendorfer et al., 1984). Divers

that do not continue to Phase II remain at the Phase I level to maintain an optimum level of fitness.

Divers enter Phase II in preparation for the task specific mission. This phase places greater emphasis on the task specific fitness training required for a particular research dive. For example, our initial research saturation dives required the subjects to pedal a bicycle ergometer for 30 min. Therefore, a task specific element of training included pedaling a bicycle ergometer for 30 min. Phase II training lasts about two weeks or longer. At least two weeks are needed to achieve the high degree of task specificity required for the mission.

If the mission is of short duration (less than 1 week) and is to be repeated frequently, the divers may cycle directly back into Phase II thereby maintaining a state of readiness for the task specific dive.



Phase I

The schedule for Phase I training is presented in Table 1. All sessions begin with warm-up exercises and stretching routines. It is our belief that proper warm-up and stretching routines reduce the incidence of injury to tendons and muscles. Stretches incorporated at the end of the session allow a period of gradual cooling down and the achievement of maximum gains in flexibility (Jensen and Fischer, 1979). Warm-up and stretching routines are presented photographically in Appendix A.

Phase I involved three days (Monday, Wednesday, Friday) of circuit weight training and running. Two training days (Tuesday, Thursday) focused on swimming and jogging. This scheduling pattern provided variety and avoided specific rigorous workout routines on successive days.

Circuit weight training is outlined in Table 2. Each routine is presented photographically in Appendix B. The circuit is a modification of the SPARTEN program used at the U.S. Navy Saturation Diving School. Our circuit is comprised of 15 exercise stations, with two (14, 15) dedicated specifically to research dive requirements. Exercise is conducted at each station for 15 s with a lapse of 15 s between stations (a 1:1 work/rest pattern). A nonexercising coordinator provides timing and encouragement. Two consecutive cycles of circuit weight training are completed each day in Phase I, requiring 15 min of work/rest activity. In addition to strength gains, this 15 min period produces some aerobic conditioning (Gettman, Ward, and Hagan, 1982; Nelson et al., 1984).

Values for the weight lifting stations (4, 5, 6, 8, 9, 13) were adjusted to be about 66% of each individual's maximum voluntary contraction. It has been shown that values less than 60% provide no significant gain in strength (McDonagh, 1984). Weights greater than 75% limit the number of repetitions

TABLE 1

Physical Fitness Training Schedule

Days	Phase I	Phase II
Mon-Wed-Fri	Warm up and stretch	Warm up and stretch
	Circuit weight training	Circuit weight training
	Stretch	Stretch
	Timed run (3-5 km)	30 min bike exercise
	Cool down and stretch	Cool down and stretch
Tues-Thurs	Warm up and stretch	Warm up and stretch
	Jog (1 km)	Jog (1 km)
	Swimming	Swimming
	Jog (1 km)	Non-timed run (3-6 km)
	Cool down and stretch	Cool down and stretch

TABLE 2

Circuit Weight Training Stations

Station No.	Phase I	Phase II	Major Muscle Groups Involved
1	Push-up	Push-up	Shoulder, arm
2	Incline sit-up	Incline sit-up	Abdominal, hip flexors
3	Arm dip	Arm dip	Shoulder, back tricep
4	Double leg press	Double leg press	Leg extensors, knee extensors, hip flexors, gluteals
5	Behind neck pulldown	Behind neck pulldown	Shoulder, latissimus, biceps brachii
6	Arm curl	Arm curl	Biceps brachii, shoulder
7	Hip flexor	Hip flexor	Hip flexors, abdominal
8	Double leg extension	Double leg extension	Leg extensors, knee extensors
9	Front shoulder press	Front shoulder press	Shoulder, triceps
10	Four-count body builder	Eight-count body builder	Shoulder, arm, hip
11	Foreward chin-up	Forward chin-up	Arm, shoulder
12	Supine flutter kick	Supine flutter kick	Abdominal, hip flexors
13	Bench press	Bench press	Shoulder, upper arm, pectorals
14	Bike ergometer	Sprint thrusters	Leg, hip
15	Hand grip	Balance beam	Forearm (I), leg, gluteals (II)

Fig. 2. Hamstring stretch. Cross one leg in front of other with back leg straight, bend over, hold 10 s. Reverse leg positions, hold 10 s.

Stretching Routines

Fig. 1. Arm stretch. Arms clasped over head. Bend laterally, hold 10 s. Bend to opposite side, hold 10 s.

WARM-UP AND STRETCHING EXERCISES

Warm-up Exercises at the Beginning of Each Training Session

Exercise	Number
Jumping Jacks	20 (four-count)
Push-ups	20 (four-count)
Sit-ups	20 (four-count)
Push-ups	20 (four-count)
Sit-ups	20 (four-count)

Guidelines for Stretching

1. Always warm up before stretching.

2. Hold stretching position statically; do not bounce.

3. Stretch to the point where resistance is felt but never to the point of pain or discomfort.

4. Follow sequentially stretches 1-6 on the following pages before lifting circuit weights or swimming.

5. Add stretches 7-8 before running.

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example, if grip strength were to be tested, but no handgrip dynamometer was available, then it might be necessary to use hand exercisers or even squeeze a rubber ball. Although exercises like chin pull-ups can strengthen forearm muscles, they are not as specific for grip strength as squeezing a hand exerciser or squeezing a rubber ball.

As the specific needs of the dive mission change, it will be necessary to update the specificity training in Phase II. It is the responsibility of the program coordinator to update the training to include specific exercises related to each mission.

The final point about modification of the program concerns its adaptability for general use. In situations like an active diving locker, where no pool or circuit weights are available, a structured program can nonetheless be implemented. Divers who are diving on a frequent basis (three or more days per week) are being "trained" in a task specific manner. These men and women are maintaining an activity level similar to Phase II of this program. Less active individuals need a structured program to maintain their fitness. Circuit weight stations can be fashioned from weight belts or empty scuba cylinders. An ocean swim can substitute for pool work or running.

PROGRAM MODIFICATIONS

The flexibility of this program allows modifications to be made without compromising objectives. Modifications can be assorted into three areas: modifications necessary for individuals, equivalent exercise substitutions, and modifications of specificity training.

Modification may be needed for individuals with acute or chronic medical disorders. Any disorder should be evaluated by the medical department and appropriate actions should be recommended to the program coordinator. For example, acute musculoskeletal problems may temporarily require a decrease in the weights required for circuit weight training. Acute viral infections may require a participant to be excused from the training program until the infection resolves. Chronic problems, on the other hand, need to be evaluated for possible exercise substitutions (e.g., pedal a bike in lieu of running for chronic ankle instability). Individuals with chronic problems also need to be evaluated as to whether the malady interferes with mission objectives and whether corrective measures are warranted.

Equivalent exercise substitutions may be required in circumstances in which either the equipment is not available or space limits the implementation of the program as presented in this paper. Substitutions can be determined with some forethought and imagination. The equivalency of the substitution is defined by the joint assurances that it uses the same muscle groups and uses them in a similar motor pattern. Any substitution in the training program must be instituted by the program coordinator to ensure the uniformity of training.

Modifications of specificity training ought to be made with some caution. If a mission's specific tasks cannot be incorporated easily into the training program, then care must be taken to duplicate the task by other means. For

aerobic fitness was implied by observed decreases in running times over fixed distances. Gains in strength of 10-45 lb were apparent in all divers for at least one of the circuit weight training stations. Handgrip strength increased an average of 7 kg over the course of four weeks during Phase I. These increases in muscular strength, coupled with a mean weight loss of 1.6 kg, implied indirectly a decrease in the percent of body fat. Six weeks into the training the divers percentage of body fat, measured by hydrostatic weighing, averaged 15 ± 3%. By way of comparison, there was an average gain of 3% in body fat after the five to 17 days of relative inactivity during decompression from the dives.

IMPLEMENTATION OF THE TRAINING PROGRAM

There are several key elements needed for the successful implementation of this physical training program. The first is command support. Everyone in the chain of command must understand the rationale for each segment of the program and must fully endorse it. It is especially important that the research divers understand the need for specificity training.

A program coordinator should be appointed to oversee and update the program when necessary. This person may assign people to lead the individual segments of the program and to maintain progress records on each participant. The coordinator must be knowledgeable in the principles of exercise physiology in order to update and modify the program according to operational goals and available resources.

Space and time need to be allocated for the conduct of the training program. Running courses need to be established in order to quantify running times. Circuit weight stations need to be marked appropriately with the weight used by each participant.

The program emphasized total body fitness according to accepted standards of exercise physiology and sports medicine (American College of Sports Medicine, 1980; Gettman, Ward, and Hagan 1982; Jensen and Fisher, 1979). Large groups of muscles in all parts of the body were used in a variety of motor patterns to achieve strength and endurance. The regimented use of total body involvement minimized the pitfalls of favoritism, whereby individuals might by preference have choosen only those routines they liked or found easy to do. Warm-ups and stretches were incorporated into each session to lessen the incidence of musculoskeletal injury and to enhance joint flexibility.

Once backed by command authorities, the training of dive teams became an integral part of the dive team's daily routine. Fitness training became an operational consideration and was not viewed as an addendum to the daily routine. The training was also practical from the standpoint of utilizing existing resources for strength and endurance exercises. The standardized format of the training program made it easy for all divers to follow.

The program allowed evaluation of peer interactions. These interactions were useful to detect personality clashes and to evaluate cooperation among members. It was possible to assess subjectively individual progress during the training phases. For example, the careful observer can evaluate the ease with which any diver attempts or completes a particular exercise. To the trained eye these indexes can be used as a subjective gauge of motivation or signs of improved fitness. Likewise, comments elicited and volunteered from the divers can be used to judge the effectiveness of the program. All divers in the inaugural program expressed the belief that the program was extremely beneficial.

It was possible to evaluate objectively some of the progress made by the eight divers who initially participated in the training. An increase in

Two sets of swimming exercises were completed. The first set involved swimming one length of the pool, then doing a poolside push-up. The number of push-ups increased by one with each successive length until 10 push-ups were reached (total of 10 swimming lengths and 55 push-ups). Divers swam odd numbered pool lengths using a crawl stroke and even numbered lengths using a breast stroke.

After completion of the first swim set, 30 four-count prone flutter kicks were done at the poolside. The second exercise set reversed the sequence of push-ups, beginning with 10 push-ups on the first length and decreasing by one for each additional length.

A run instead of a jog occurred after the swim. Running distance was about 3-6 km. A comfortable running pace was maintained for about the first half of the distance, then everyone was encouraged to run at their fastest pace for the last half of the distance. Cool down and stretching exercises followed the run.

EVALUATION OF THE TRAINING PROGRAM

Eight divers initially underwent the physical training program in preparation for three research saturation dives to 200, 300, and 1000 ft of seawater. These divers entered the program with a variety of physical training backgrounds. The initial trial of this program afforded an opportunity to evaluate it in terms of theoretical soundness, mission goal, practical implementation, and future modification. The program was designed to prepare divers as research subjects in a task specific manner. This follows the adage that the best training for an event is the event itself. Bicycle riding and handgrip exercises afforded the opportunity to train the research divers in a task specific manner before the onset of the research dives.

As noted in Table 1, the format remains nearly the same as in Phase I. The emphasis in Phase II is on a higher intensity of work and a greater degree of task specificity.

Maximum voluntary contractions were retested at the beginning of Phase II to determine if the weights in the circuit weight training needed to be adjusted upward. Circuit weight training was raised to three circuits, maintaining the 15 sec work cycles (1:1 work/rest ratio). Increasing work periods to 30 sec was counterproductive because it hastened fatigue and led to a decrease in the total number of repetitions done over three circuits.

Station 10 in the circuit weights was changed to an eight-count body builder to increase the emphasis on shoulder/arm power. Station 14 was changed to sprint thrusters to promote leg power. Station 15 became a routine of alternately balancing on one leg with the opposite leg extended.

Phase II was used to increase the specificity of training. For our initial requirements this entailed handgrip exercises and a prolonged session of bike pedaling. Both exercises were separated from the circuit training and used in lieu of running on the Monday-Wednesday-Friday routine. Maximum handgrip force was exerted on a handgrip dynamometer with an attempt to maintain force for 60 sec. This was done with each hand. Four bicycle ergometers were used simultaneously with each diver exercising for 30 min at a workload of 2 W/kg body weight. While one dive team pedaled the bikes the other dive team did the circuit weight training.

The Tuesday-Thursday swim routine in Phase II was varied somewhat. The sessions began with the usual two sets of sprints (three lengths each). Thirty four-count supine flutter kicks were done after the first sprint set and 30 four-count supine leg spreads were done after the second sprint set.

stroke required slightly different contributions of upper body muscles. Twenty four-count supine leg spreads were then done as a group at the poolside. This calisthenic was chosen specifically to work both the abdominal and abductor/adductor hip muscles.

The three sprint lengths were then repeated and followed by 20 four-count supine flutter kicks at the poolside. The supine flutter kicks were chosen to exercise upper and lower abdominal muscles.

Program participants were divided into two or more teams for swimming relay races. The spirit of competition during the races encouraged maximum effort by each individual. The relay events were chosen to exercise specific body regions. One lap (50 m) was done utilizing a kickboard to exercise primarily the leg muscles. A second lap was done with a styrofoam pull buoy held between the legs to exercise primarily arm and shoulder muscles. Each lap was done by all divers. Two sets of races were held daily. Twenty four-count prone flutter kicks were done between the races to exercise lower back and gluteal muscles.

The final swimming exercise of the day was a 15 min continuous swim. A circular swimming pattern was chosen to avoid the tendency to stop after the completion of each lap. Any swimming stroke could be used during the continuous swim.

Upon completion of the swim the group jogged back to the compound and did the stretching exercises presented in Appendix A. The total time for this training day was about 1.5 h.

Phase II

After four to six weeks the divers are ready to enter Phase II. The shift to Phase II depends upon evaluation of the progress made in Phase I and on operational considerations. Daily time requirements are about the same as in Phase I.

that can be done in the allotted time. Each participant is instructed beforehand in the proper techniques for lifting and breathing during each exercise. Emphasis is placed on using the weights over a full range of motion and on avoidance of isometric straining. Stretching exercises followed the circuit weight training in preparation for a timed run. These stretches focused on flexor and extensor muscle/tendon groups of the lower extremities.

Aerobic conditioning was achieved by timed runs over 3-5 km (2-3 mi). Trainees were encouraged to run the distance as fast as possible without stopping. Individual times were kept by the program coordinator to track progress. Course distance was selected to produce running times greater than 15 min. As times improved, the program coordinator lengthened the distance to keep times equal to or greater than 15 min.

The program coordinator provided guidance in proper running technique. Acute or chronic orthopedic problems were evaluated medically, and, when necessary, alternative aerobic exercises were recommended.

The final stretching exercises after running allow the body to cool down and also increase joint flexibility. These daily training sessions last approximately 1.5 h (including final shower and dressing).

The other two days of Phase I training (Tuesday, Thursday) centered around swimming activities. Apart from variety, the swimming served two useful training purposes. The first was to provide more comprehensive endurance training for the upper body. The second purpose was to use body muscles in slightly different motor patterns from those associated with circuit weight training and running.

Warm-up and stretching exercises were followed by a 1 km jog to the swimming pool. Pool workouts began by sprinting three lengths of the pool (25 m per length), one length each of crawl, breast, and side strokes. Each

Fig. 4. Back stretch. Legs spread 2-4 ft, bend forward in mid-line, hold 10 s. Shift to one side, hold 10 s, shift to other side, hold 10 s.

Fig. 5. Arm rotations. Swing arms in giant circle for 20 four-count revolutions. Reverse direction for 20 four-counts.

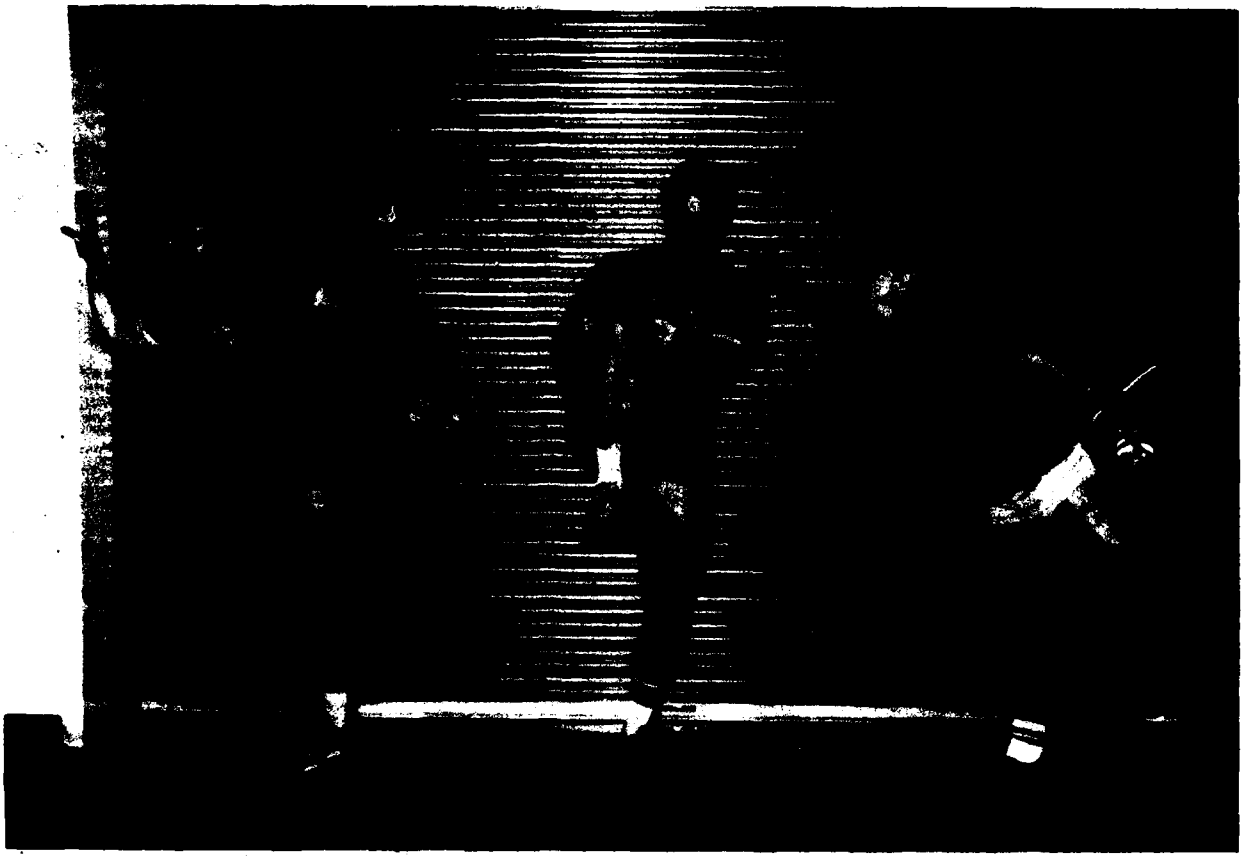

Fig. 6. Thigh/buttocks stretch. Grasp one leg above ankle, raise leg to chest, hold 10 s. Pull leg backwards to buttocks, hold 10 s. Extend bent leg laterally, hold 10 s. Repeat with opposite leg.

Additional Stretches Before and After Running

Fig. 7. Achilles/gastrocnemius stretch. Lean against wall, one leg fully extended about 4 ft from wall, forward leg about 2 ft from wall, hold 20 s. Reverse position, hold for 20 s.

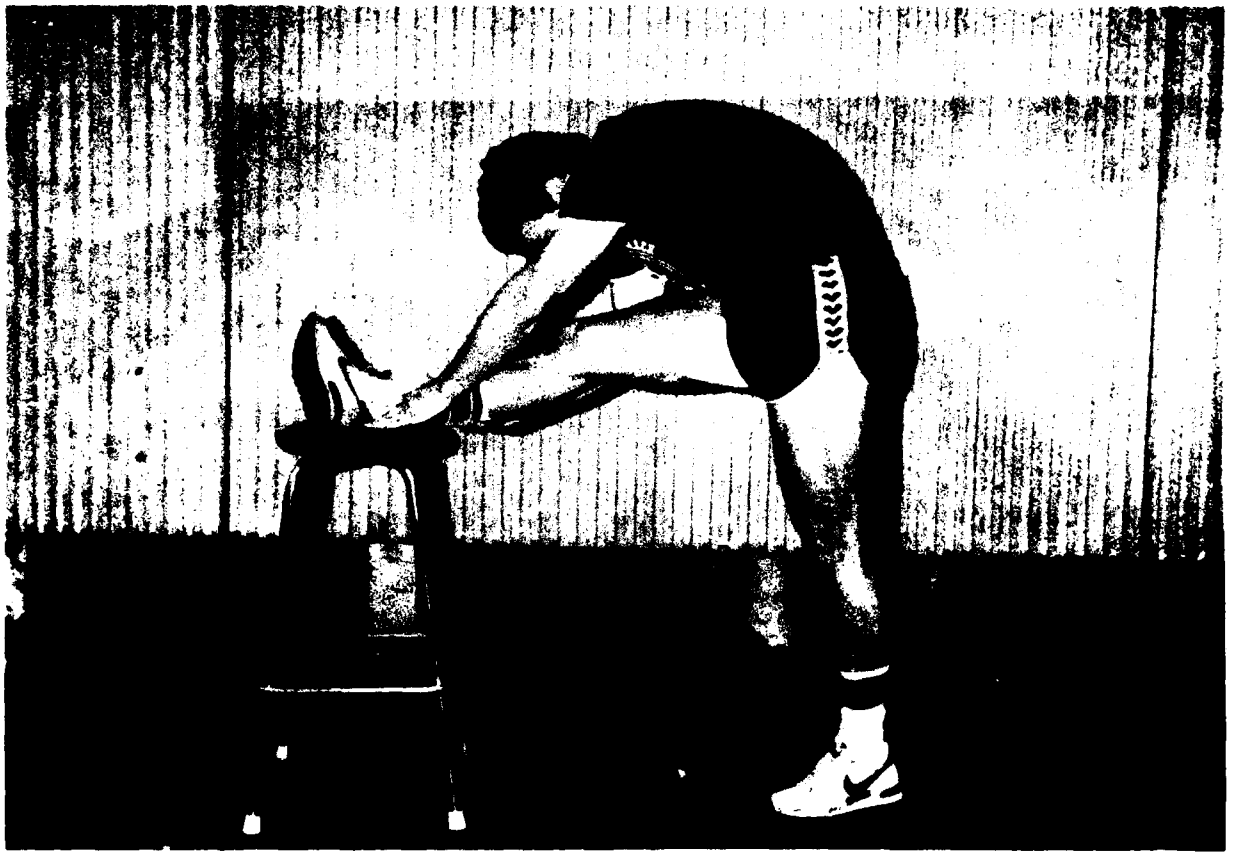

Fig. 8. Hamstring stretch. Support one leg 2-4 ft above ground, lean forward, and touch ankle. Hold for 20 s. Repeat with opposite leg.

CIRCUIT WEIGHT STATIONS

Fig. 9. Station 1: Push-up. Arms extended fully in up position. Lower body until chin is close to ground. Repeat as fast as possible.

Fig. 10. Station 2: Incline sit-up. Board inclined at 30-45°, knees bent, arms across chest. From full recumbent position, sit up until elbows reach knee level. Repeat as fast as possible.

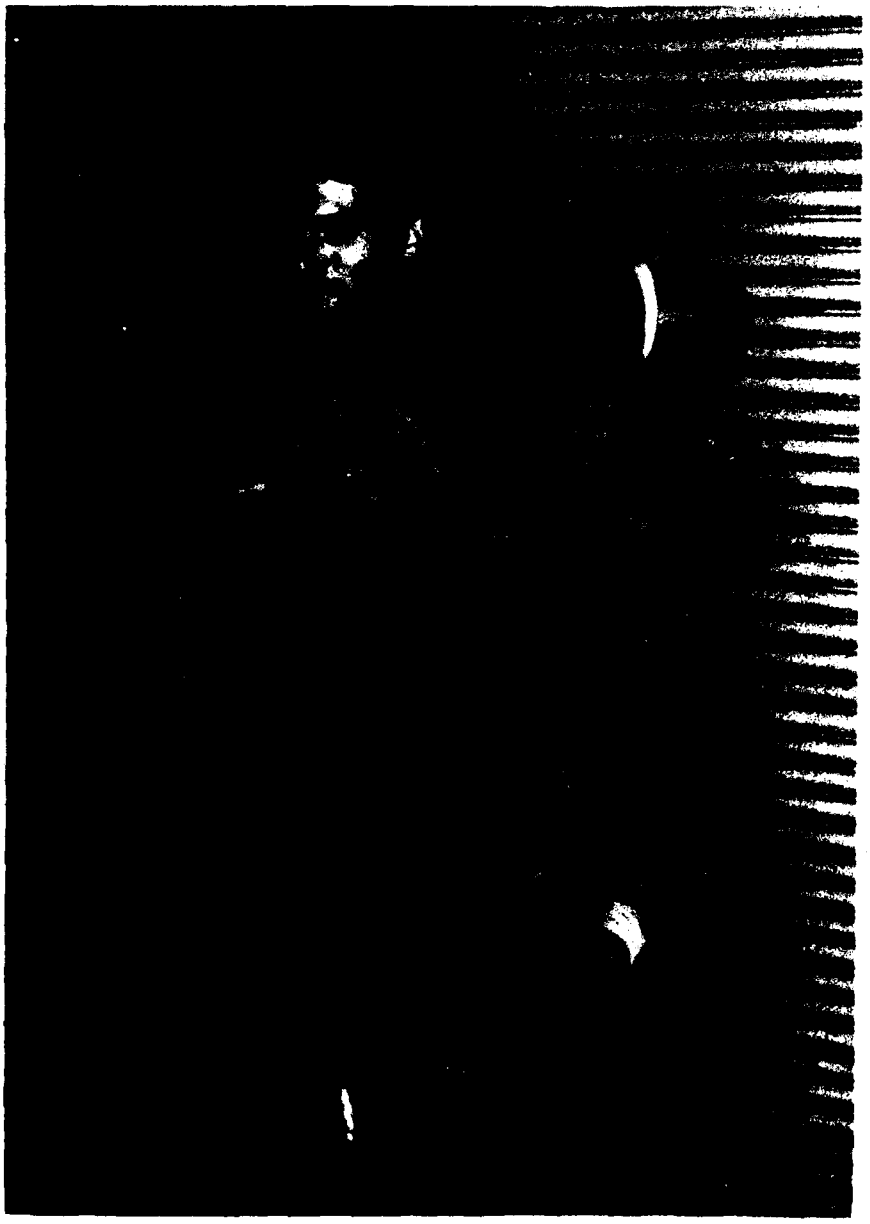

Fig. 11. Station 3: Arm dips. Begin with arms extended fully and feet off ground. Lower body until arms bend.

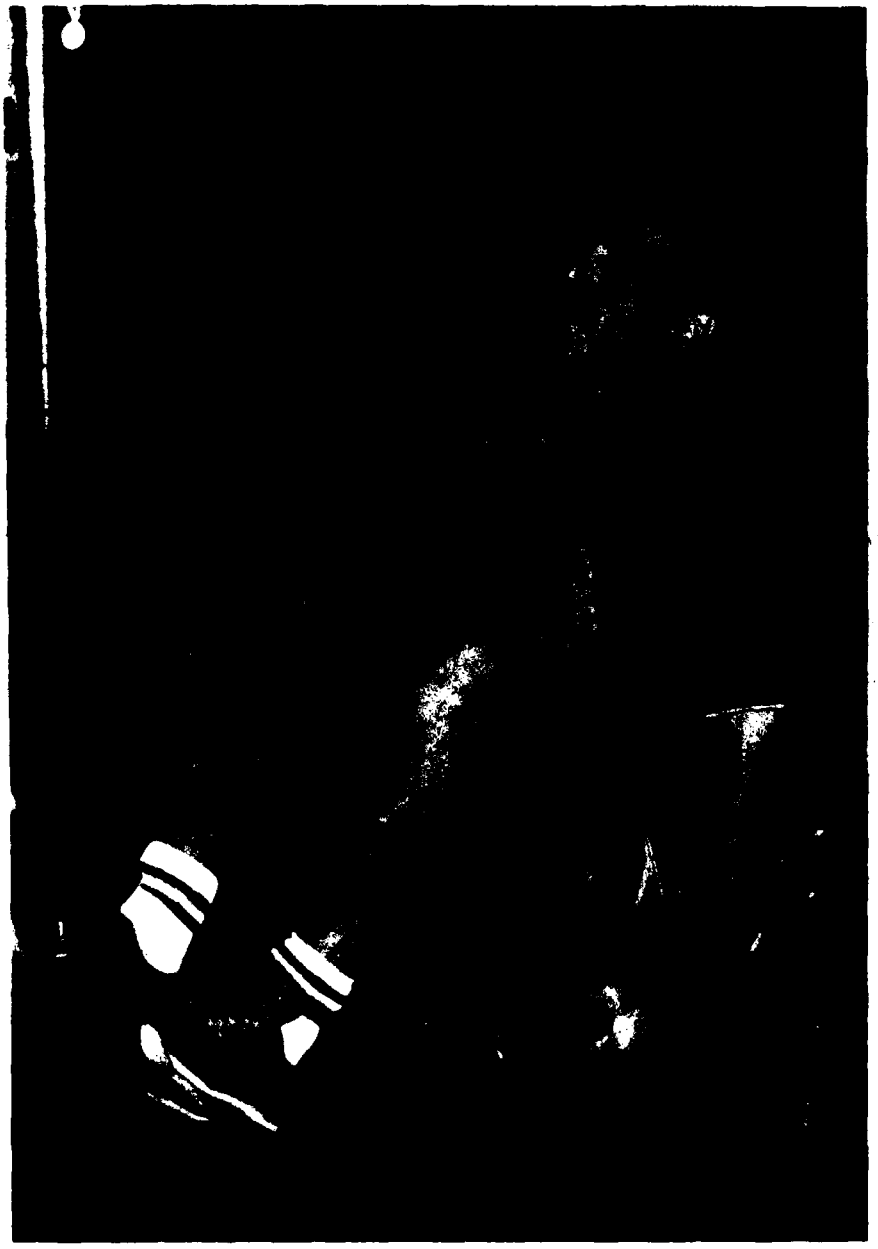

Fig. 12. Station 4: Double leg press. Adjust seat so legs are bent about 90°. Fully extend legs, exhaling as leg force is applied. Inhale during return movement.

Fig. 13. Station 5: Behind neck pulldown. Kneel on floor, grasp bar with arms extended fully. Pull bar down behind head, exhaling as you pull. Inhale during upward movement of bar.

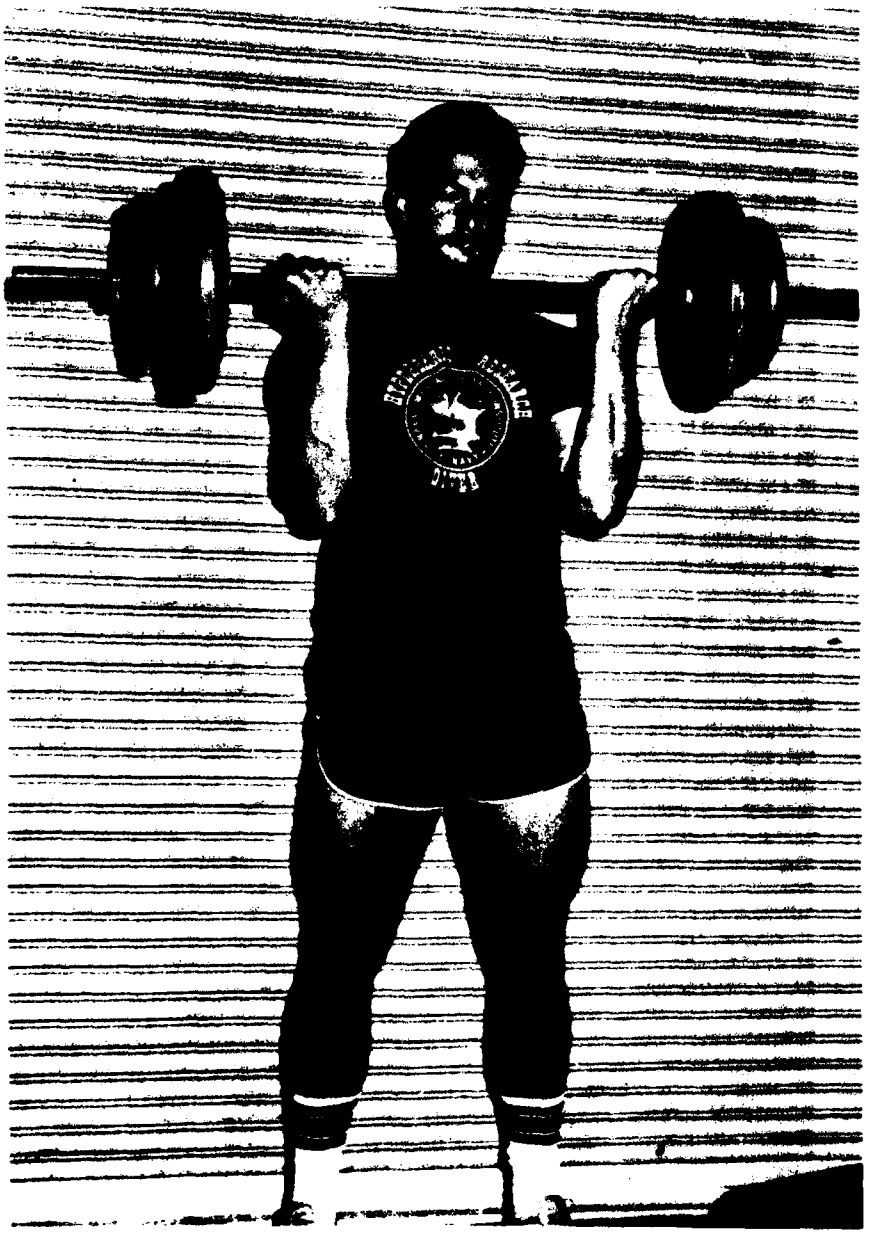

Fig. 14. **Station 6: Arm curl. Begin with weights held at hip level. Curl forearm upward toward chest without bending trunk. Exhale during upward curl, inhale on downward movement.**

Fig. 15. Station 7: Hip flexor. Support body with arms bent at 90°, legs straight. Raise both legs up toward chest.

ig. 16. Station 8: Double leg extensions: Begin with legs at 90°, fully extend legs. Exhale during extension, inhale during return flexion.

Fig. 17. Station 9: Front shoulder press. Seated on stool, feet off floor. Push bar upward until arms are extended fully. Exhale during extension, inhale during return flexion.

Fig. 18. Station 10: Four-count body builder. From upright position, first count assume squat position, second count fully extend body to push-up position, third count spring back to squat position, fourth count stand upright. In Phase II, two push-ups are added after body is extended.

Fig. 19. Station 11: Forward chin-up. Palms facing forward, feet off floor. Pull up until chin is at bar level.

Fig. 20. Station 12: Supine flutter kick. Background: Lying on back, legs off floor, alternately raise and lower legs a distance of 2-4 ft. Foreground: position of prone flutter kick used during poolside exercises.

Fig. 21. Station 13: Bench press. Lay on bench, feet resting on floor. Raise weights until arms extended fully. Lower to full resting position. Exhale during extension, inhale during return to resting position.

Fig. 22. Station 14: Bike ergometer (Phase I). Leg flexed slightly when pedal in full down position.

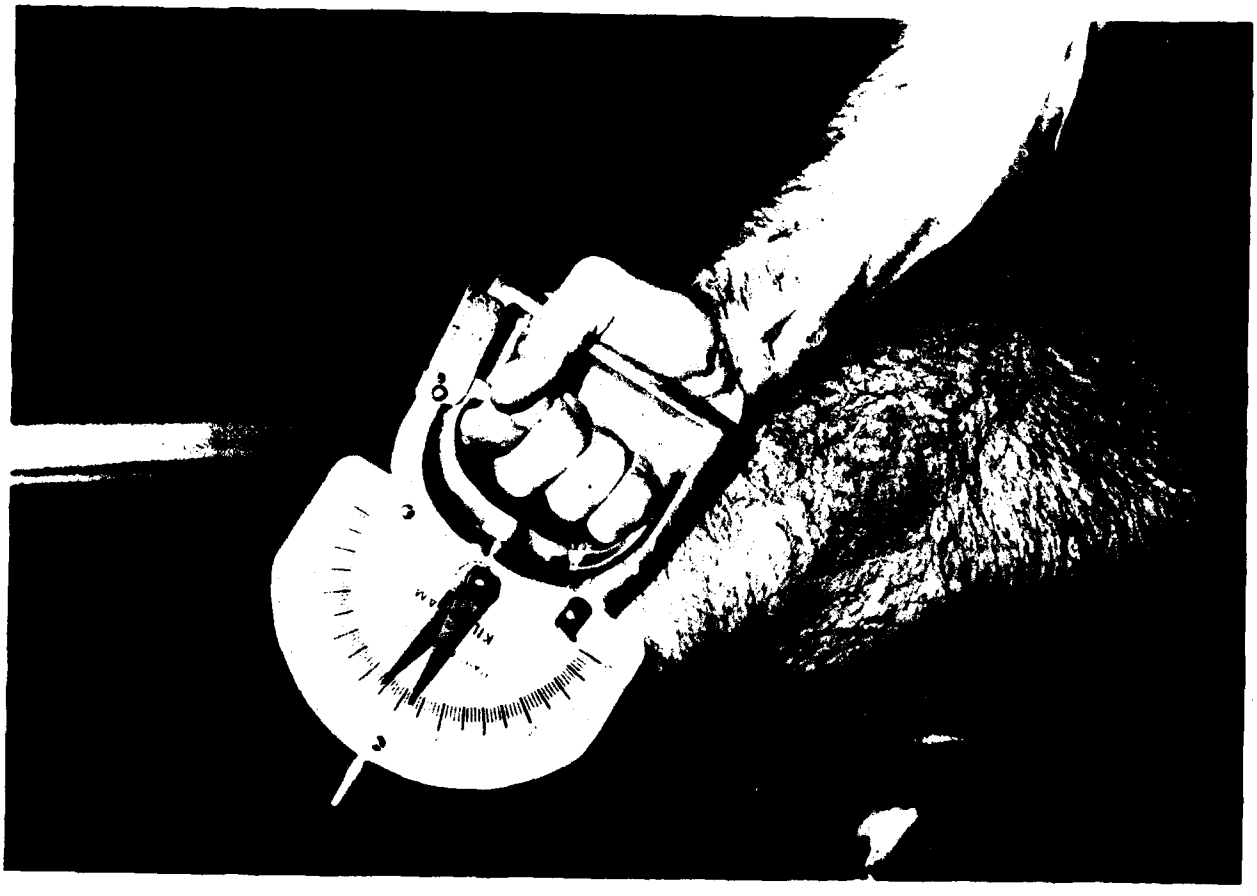

Fig. 23. Station 15: Hand grip (Phase I). Grip adjusted for second finger joints to lay across bar. Maximum grip force exerted. Repeat with other hand.

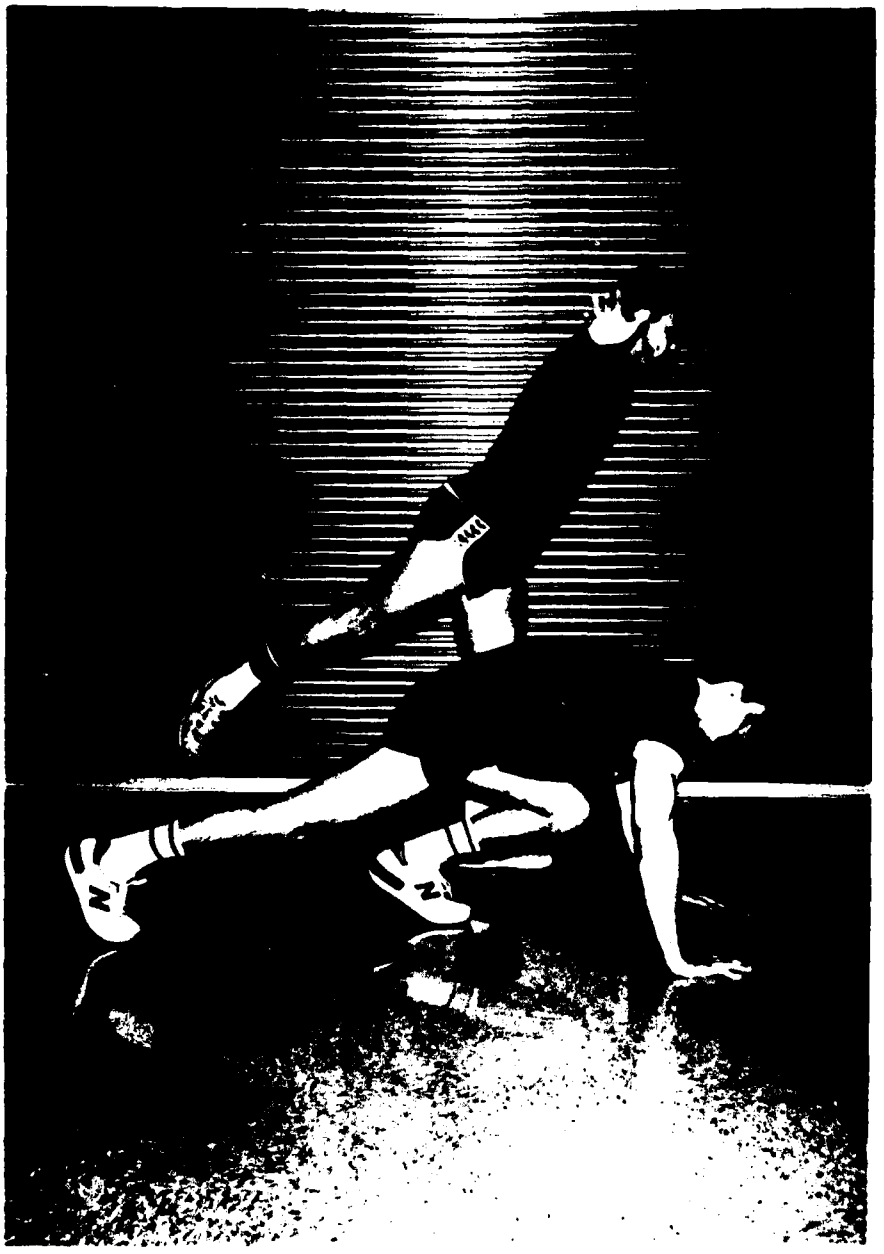

Fig. 24. Station 14: Sprint thrusters (Phase II). From push-up position, draw one leg up to chest. Rapidly extend leg while drawing other up to chest.
Station 15: Leg balance (Phase II; background). Balance on one leg with other leg extended to rear. Hold 7-8 s, and repeat with other leg.

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